

The Use of Interactive Technology and Virtual Reality in Support of the Naval Special Warfare Mission

Glen H. Wheless and Cathy M. Lascara
Virtual Environments Laboratory
Center for Coastal Physical Oceanography
Old Dominion University
Norfolk, VA 23529

Phone: (757) 683-5556 Fax: (757) 683-5550 E-mail: wheless@ccpo.odu.edu
lascara@ccpo.odu.edu

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<http://www.ccpo.odu.edu/~vel>

LONG-TERM GOAL

The long-term goal of this project is to develop and to deploy an interactive application that displays relevant METOC, targeting, and threat information in support of Naval Special Warfare (NSW) scenario-based mission rehearsal activities, with a primary emphasis placed on the mine countermeasures domain. The integration of near real-time observations collected by autonomous sensors or swimmer scouts will be explored as a capability of the application. This effort will use the Collaborative Virtual Environment (CVE) as its basis and will be optimized for use on projection-based virtual reality (VR) systems like the Immersadesk or CAVE™. A secondary goal will be the definition of a transition path from the higher end systems to lower-end desktop machines. Finally, a collaborative capability that enables interaction from within the CVE between multiple users and other applications at distributed sites will be included. This effort is applicable to the NSW requirements for intuitive battlespace visualization and also fits within the Very Shallow Water Mine Countermeasure (VSW MCM) thrust.

OBJECTIVES

The original objectives of this project were to design and begin the initial development of a system useful for mission planning and rehearsal for the NSW community. We have subsequently redirected our efforts to the mission rehearsal phase and will focus on developing an interactive, collaborative, graphical 3D CVE specific to the NSW mission. Using the CVE approach changes the way information is viewed and manipulated, and provides a sense of presence to the user that aids in the mental process of assimilating complex mission critical information. Our approach has been shown to be useful in mission/campaign planning and rehearsal efforts by providing intuitive information to the warfighter and the command and staff levels on the undersea bathymetry and bottom composition, currents, water levels and water mass distribution in the littoral zone.

Objective One. We will construct an NSW-specific mission rehearsal application. This application will create a common tactical picture from multiple sources of data and will make this common picture available as a collaborative virtual environment on a shared battlespace network. Capabilities of the application are based upon an analysis of the current NSW MCM mission and focused on important

environmental/METOC variables and critical tactical data most important to a successful NSW mission rehearsal scenario or post-mission analysis.

Objective Two. This objective will be completed by an advanced technology demonstration through the use of the VR devices at the Center for Coastal Physical Oceanography, Old Dominion University. A specific domain of interest and other pertinent demonstration parameters will be chosen by consultation with the Principal Investigators (PIs) and ONR program managers.

APPROACH

We have used our experience designing and constructing other VR applications as our point of departure for the Virtual Special Warfare Mission Rehearsal System (VSWMRS), an interactive VR-based application developed to support NSW scenario-based mission rehearsal activities. VSWMRS is a run-time configurable application that uses the paradigm of virtual reality as its fundamental concept of operations. VSWMRS is capable of constructing a navigable, three-dimensional graphical representation of the target area of interest, including visualizations of bathymetry/topography, above-surface images, in-water objects (e.g. mines, bridges), and hydrographic characteristics (e.g. currents, water levels, temperature). The initial information needed to construct the virtual environment is provided by archived data sets residing on local or distributed data stores. The system also integrates near real-time track data and observations collected by autonomous sensors or swimmer scouts. Typical laydown information includes circulation, water properties, levels, and external objects. Users are able to navigate through and interact with the data and graphical objects. All visualizations are optimized for stereo display.

Key personnel participating in this effort have been Dr. Glen Wheless and Dr. Cathy Lascara, co-directors of the ODU Virtual Environments Lab, who have provided technical guidance and direction to the project. Also, Mr. Ray Weinig and Mr. Kevin Curry, both research assistants at the Old Dominion University (ODU) Virtual Environments Laboratory (VEL), have provided programming expertise.

WORK COMPLETED

In this third year of the project, we have continued to build on our earlier work and to extend the capabilities of the application. We have also focused on ensuring that user interaction within the CVE is easy and intuitive.

Due to the deficiencies in our less functional VR prototyping application, Cave5D, especially in the ability to place irregularly shaped objects within the virtual environment, we designed a new base code structure. Our new structure ensures easy ingestion and display of generic data in a variety of formats as well as irregular objects such as bridges, mine-like objects and moving sensors.

VSWMRS has been designed as a CAVELib-based application and uses the VRtigo™ API from VRCO, Inc. for much of the user functionality within the virtual world. The collaborative capabilities inherent to the CAVELib API have been included so that multiple participants may join the CVE and interact with the data and with each other. The management of stereo projections and tracked interface devices is accomplished using the CAVELibs.

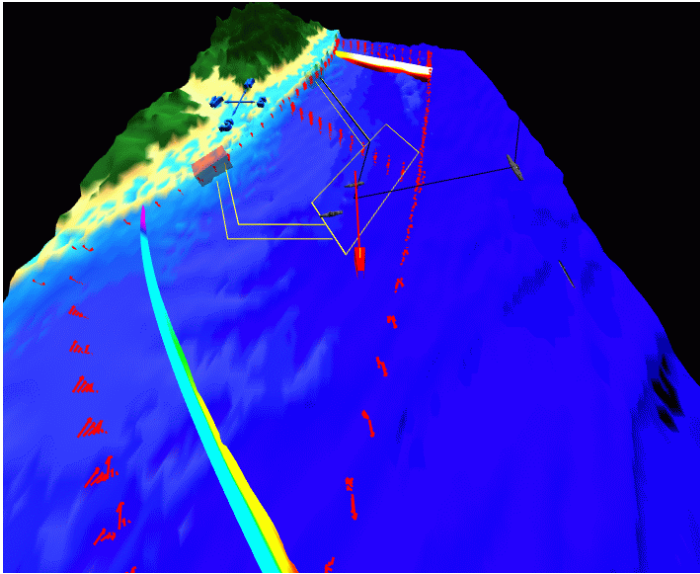
In order to more effectively manage all graphical objects within the CVE, we have chosen the implementation of a Hierarchical Scene Graph approach and are using the scene graph known as Performer. The construction of polygon geometry from data objects is now handled by the publicly available package called Visualization ToolKit (VtK). VtK supports the construction of graphical objects from regular as well as irregularly gridded data sources and runs on platforms that support the OpenGL graphics library.

The additional capabilities made available by the VRtigo™ API are considerable. During this year, the following features were added to or improved upon:

1. A CVE may have multiple time and space coordinate systems defined. Each spatial coordinate system may be manipulated independently in the CVE. This has application for displaying data collected by remote instrumentation or many Autonomous/Unmanned Underwater Vehicle (AUV/UUV)-based sensors with different collection rates.
2. Grid data objects support grid lines that are not orthogonal to the coordinate system, thus, allowing for curvilinear grids. This has application to the visualization of numerical circulation model data.
3. User control of color display for data objects has been enhanced to include linear spectrums and lookup tables. Further, a user may now interrogate a color palette from within the CVE and obtain information about the range of data being portrayed. This has application to analysis functions from within the CVE.
4. A new data type called moving sensor data objects was implemented to support multiple measurements collected by moving sensors. This has application to the data collected by AUV/UUV's in the littoral MCM mission.
5. Visualization of Raster-based images is now supported. The images must be SGI rgb file format, but many products available to convert from gif, jpeg, etc to rgb. This has application to the display of remotely sensed data overlaid upon terrain data or shown in addition to other types of data in the CVE, thereby aiding in the assimilation of many pieces of data.
6. Selected 3D model types can now be visualized in the CVE, including Inventor files, Multigen files, or Performer objects. This has application to the intuitive display of objects in the CVE in battlespace visualization for command and control.
7. Data may now be decimated or sub ranged on the fly during visualization process by a user in the CVE using a 3D widget-like object. This has application to analysis of complex data.
8. Visualization of text strings using Performer fonts is supported. This has application to the identification of objects.
9. Group hierarchy is supported for graphical objects so that groups of objects can be turned on/off as a single action thereby allowing large groups of data to be combined and displayed then turned off as in a de-clutter type of operation.
10. Different styles of navigation methods for movement through the CVE has been implemented, including a Drive style and a 6 degree-of-freedom Fly style.
11. A Target Identification Display has been implemented so that information about specific track data may be seen in the CVE, including range, bearing, altitude, heading, velocity and altitude. This has application to analysis of tactical data from within the CVE.

RESULTS

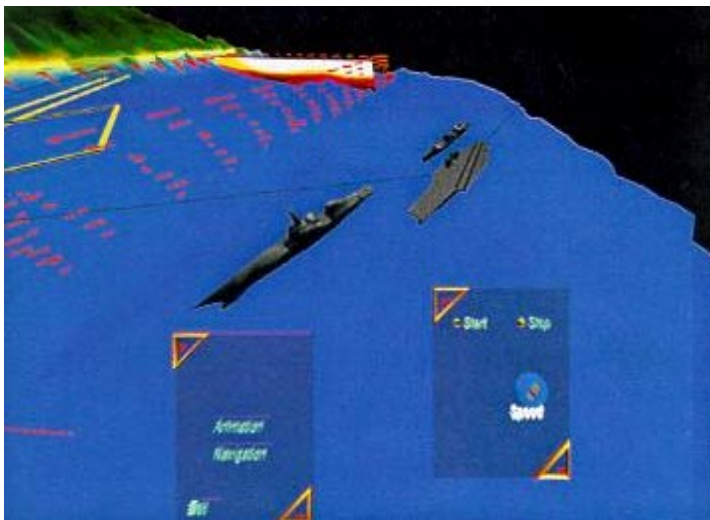
The most significant result from FY2000 is that the latest version of VSWMRS is a truly configurable, collaborative virtual prototyping application that enables immersive virtual environments to be quickly created from terrain data, tactical information (vehicle position and PIM, craft landing zone, underwater object location and type, etc.), numerical model results and environmental observations.



The images on this page demonstrate VSWMRS capabilities. In this instance, an amphibious landing exercise off the coast of New Jersey has been chosen as the displayed scenario. Undersea bathymetry and terrestrial topography are displayed as colored graphical objects. Ship positions, PIM and track are also shown, along with the landing craft staging area, assault lanes and craft landing zones. Mine positions are also displayed but not visible in the images. A user may virtually touch the mine and see an image or test describing the latest information available about the object. Model results provided by the Rutgers modeling group (ONR POC: Dr. Tom Curtin) from the LEO-15 site off of the

coast of New Jersey are displayed in each image as red 3D velocity vectors, and color slices of salinity and temperature.

The 3D ship models change position in the world based upon user entered coordinates but could easily be maneuvered based on Global Positioning System (GPS) coordinates received across the network or on wireless link. Another significant result is the addition of the ability for network-based participants are able to enter the CVE and interact with each other and the data. For example, in its present form VSWMRS will allow a Battle Group Commander to view the mission area of interest and all ancillary information in an easily understand fashion as well as interacting with other mission participants who might be using similar devices yet located across the country.



All images represent 2D views into what are inherently immersive environments best viewed in stereoscopic 3D in a CAVE or on the Immersadesk.

IMPACT/APPLICATION

The development activities outlined above are designed to enable our long term goal of enabling the NSW community to utilize an immersive 3D virtual environment for mission planning and rehearsal in a collaborative fashion. It has also been designed as a collaborative command and control application.

TRANSITIONS

Several activities previously handled by the ODU VEL have been now taken on by VRCO, Inc., a defense R&D firm. Wheless and Lascara are both principals in VRCO. This effort will be transitioned to VRCO in FY01 for further extension. Along with the CAVELibs and the trackd utility, VRCO also has developed and distributes applicationd built with the VRtigo™ API. VSWMRS was built using the CAVELib and VRtigo™ API and as such, can be easily ammended. Several other applications also built in like manner are in operation at other facilities. One such variant, the Virtual Tactical Display, is in use at the Fleet Advanced Supercomputing Technology Center at NSWC Port Hueneme Dam Neck Detachment, Dam Neck Virginia. VRCO also works closely with programs at NSWC Dahlgren's Coastal Systems Station including the TVSS and SAHRV programs.

RELATED PROJECTS

In conjunction with this project, ODU was funded to establish a CAVE facility under the DURIP program in 1999. The CAVE Facility is used routinely by this project.

We have become involved with the ONR-sponsored Coastal Modeling and Forecasting Effort, focused on the rapid modeling of the coastal area around the LEO-15 site in the coastal waters of New Jersey (ONR POC: Dr. Tom Curtin). We also continue our ongoing development of CVE creation tools with (1) the Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago, focusing on collaborative aspects, and (2) with collaborators in the National Computational Science Alliance for further development of the capability for recording, archiving and interaction within the virtual environment.